Atmospheric Modeling and Winds

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Atmospheric Modeling

Atmospheric profiles

Temperature, Pressure and Density

Surface (-4.181 to -1.3 km) to 200 km

Monte-Carlo profile families

Moderate dust load ($\tau \sim 0.3$)

Based on:

- Ames MGCM results
- TES atmospheric retrievals
- Viking Lander pressure measurements
- Pathfinder surface meteorological measurements

Limits landing elevation to -1.3 km or lower

Near Surface Atmosphere

Diurnal cycle

  winds

  Near-surface and surface tempreature

Limits the mission lifetime

Limits the science return

May limit equipment survivability

Mesoscale Wind Modeling

Almost no wind data for near-surface equatorial Mars

Mesoscale Models

- Model meteorological phenomena
  - few km to 100 km scale
  - some important phenomena unresolved
- 3-D dynamical atmospheric models
  - track pressure, temperature, wind vectors...
  - non-hydrostatic equations
  - slope illumination and shadowing
- Use nested grids for high resolution
  - cover area of interest
  - necessary context at lower resolution
- Computationally very expensive

Mesoscale Atmosphere Models

Use 2 models to check validity

MRAMS: Scott Rafkin (SJSU)

Based on terrestrial RAMS (U Colorado)

Uses Ames MGCM as boundary condition

Kinetic energy conserving grid

$\sim$ 1.5 km highest horizontal grid spacing

Very high resolution Large Eddy Simulation (LES)

Mars MM5: Anthony Toigo (Cornell) Mark Richardson (Caltech)

Based on terrestrial MM5 (U Penn.)

Uses GFDL MGCM as boundary condition

Vorticity conserving grid

$\sim$ 600 m highest horizontal grid spacing

Interactive dust transport

EDL Wind Analysis

Qualitative Study

Understand site setting

Engineering parameterization

- Effective (DC) mean wind field

  Exponential weighting function

- Scaling MPF shear/turbulence model

  MPF model reasonable, but not ideal

  Long wavelength by Fourier analysis

  Short wavelength by scaling TKE

Engineering wind profiles

Allows use of EDL Monte-Carlo modeling

Random/selected mesoscale profiles

Add high frequency turbulence

Peer Review

Successful peer review on March 8, 2002

Panel: R. Zurek, J. Barnes, D. Crisp, J. Murphy, R. Pielke, N. Renno

Also attended by project management, scientist and engineers

Review Results:

- Models are reasonable
  - Consistent with atmospheric physics principles
  - Consistent with expectations
    - season, latitude and topography
  - Model intercomparison
  - Agreement with Pathfinder meteorological data
- Analysis techniques are appropriate
- Site to site differences are significant

Hematite Overview

Little topography

Low background wind

inbetween the tropical jets

Highly convective

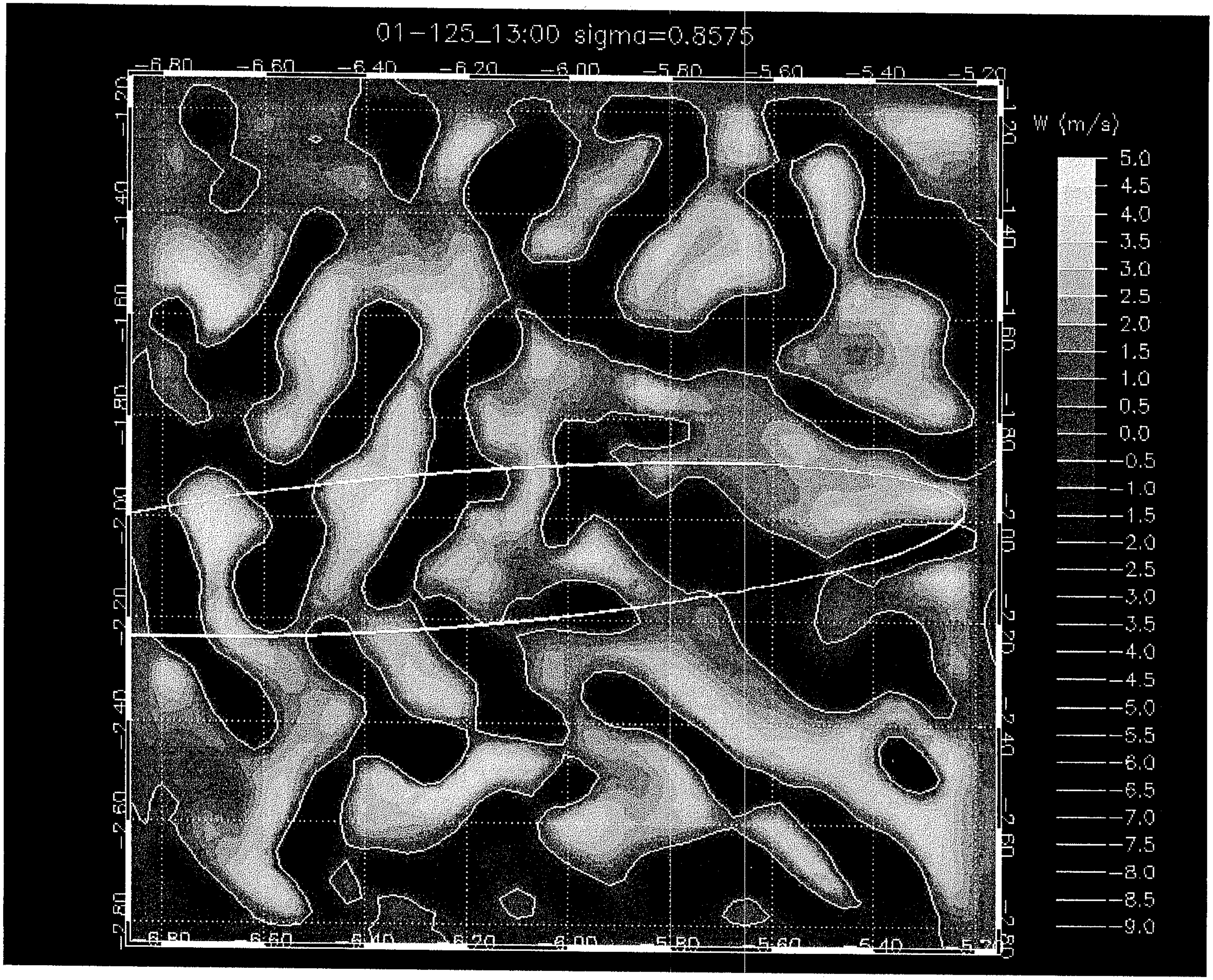
small craters enhance convection

Thick boundary layer (≥ 5 km)

Significant updrafts and downdrafts

	MRAMS	Mars MM5
Effective (DC) Wind (m/s)	4 ± 2	4 ± 2
Upward mean wind (m/s)	2.5(1.9)	1.4
Downward mean wind (m/s)	$-1.1(-1.5)$	-1.7
MPF Scale Factors		
Shear	0.4(0.3)	0.2
Average Turbulence	0.7	
Peak Turbulence	1.2	

- Values in parenthesis are from the LES
- Shear is long wavelength variability.
- Turbulence is short wavelength variability.
- Mean Turbulence is over convective boundary layer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W (m/s)
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-8.5
-9.0

Gusev Overview

In southern (eastward) tropical low-level jet

Strong crater rim upwelling and interior subsidence

- modified by global circulation
- eastward cross crater confined flow
- significant wind shear

Thin convective boundary layer

- locally enhanced turbulence

Strong nighttime katabatic flow

	MRAMS	Mars MM5
Effective (DC) Wind (m/s)	7 ± 2	3 ± 0.6
Upward mean wind (m/s)	0.4	0.3
Downward mean wind (m/s)	−0.2	−0.3
MPF Scale Factors		
Shear	0.9	0.5
Average Turbulence	1.8	
Peak Turbulence	2.1	

- Shear is long wavelength variability.
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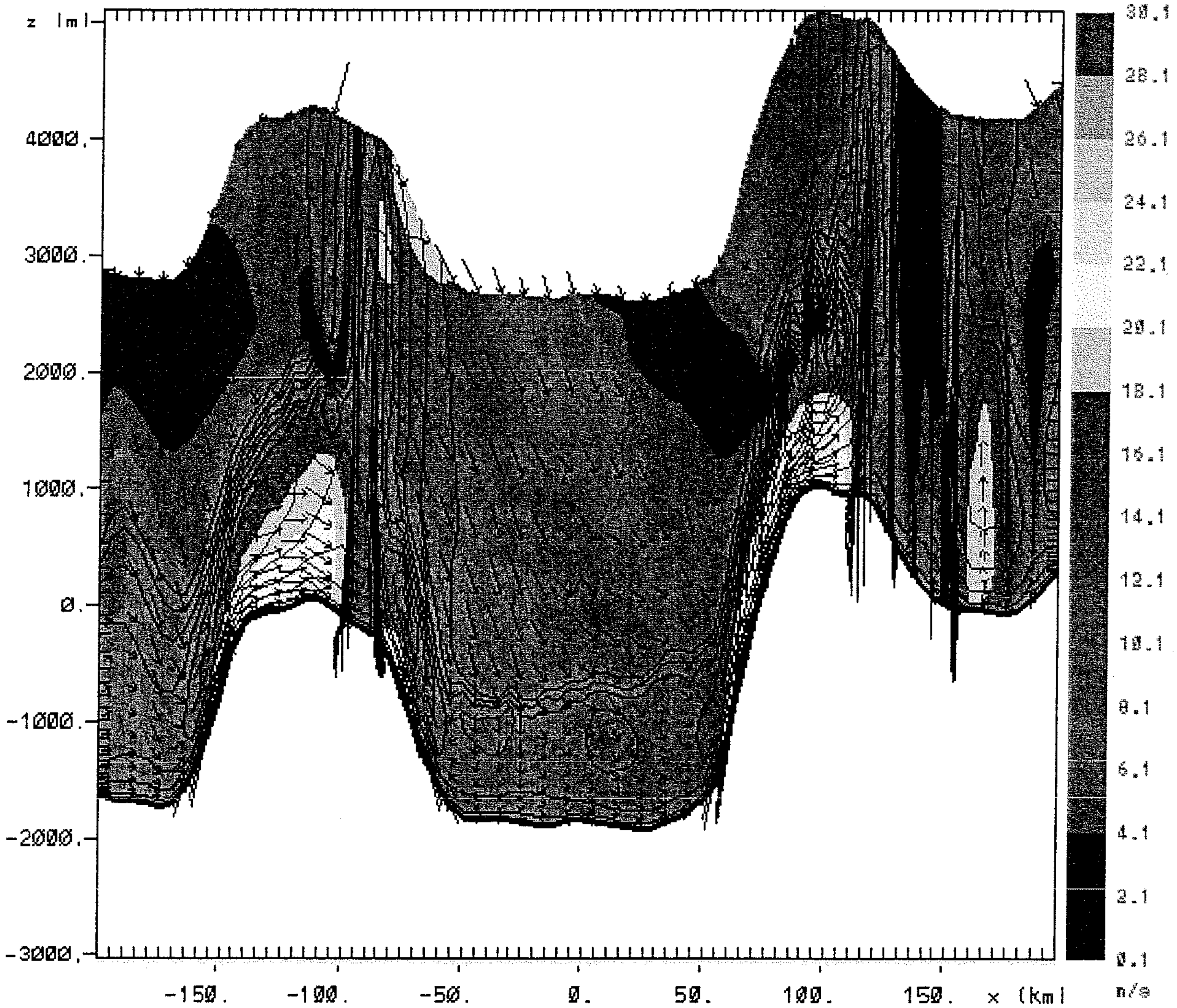
- Mean Turbulence is over convective boundary layer



Guse		grid 4			
y = −2. km	295920.00s [0200 UTC +4 sols]	min	max	inc	lab*
contours	speed (m/s)	0.7526	28.14	2.000	1e 0
contours	turb kinetic energy (m2/s2)	0.4995E−03	14.85	1.000	1e 0
vectors →	10 m/s horiz 0.21 m/s vert	0.7462E−01	25.72		

Melas Overview

Canyon driven circulation

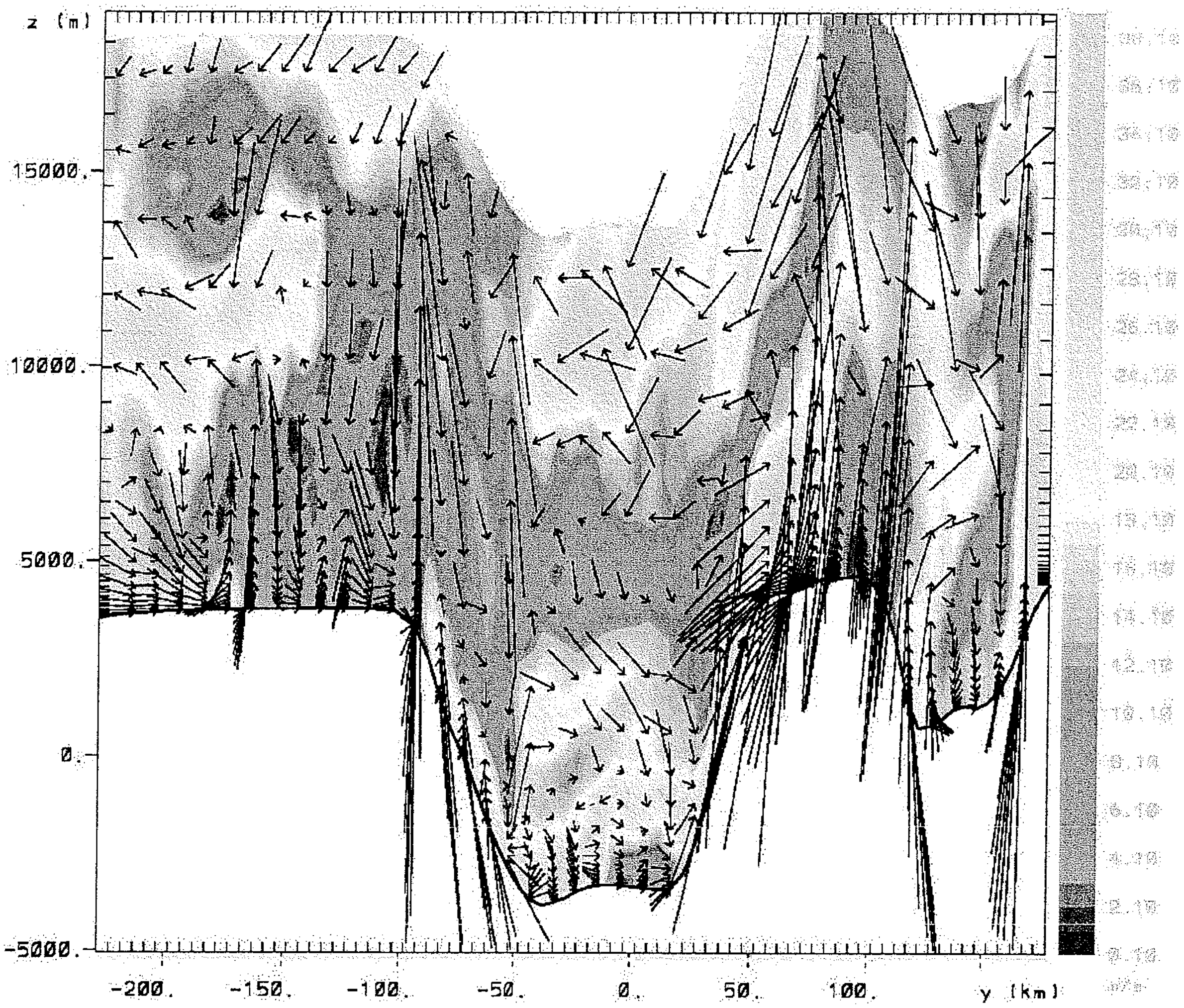
- nighttime down canyon flow
- daytime up-canyon flow
- calm during flow reversal

Large up-canyon (westerward) flow

- enhanced by westward tropical jet
- enhanced by thermal tide
- enhanced by Tharsis katabatic venting
- models disagree on timing

Extreme up-wall local flow

- canyon center subsidence
- depressed convective boundary layer
- sideways thermal "venting"
- maintain remnant down-canyon layer



Melas		grid 4			
x = −2243. km	43164.00s [1910 UTC +0 sols]	min	max	inc	lab*
contours	speed (m/s)	0.2377	43.08	1.6000	1e 0
contours	topo (m)	0.0000E+00	0.0000E+00	0.0000E+00	1e**
vectors →	5 m/s horiz 0.30 m/s vert	0.4974E−01	44.35		

Melas Statistics

	MRAMS	Mars MM5
Effective (DC) Wind (m/s)	14 ± 5	$1.3^{*} \pm 0.7$
Upward mean wind (m/s)	0.7	0.1
Downward mean wind (m/s)	−0.8	−0.1
MPF Scale Factors		
Shear	0.8	0.5
Average Turbulence	1.6	
Peak Turbulence	2.8	

* Speeds are signficantly higher 2 hours later (6 ± 3 m/s)

- Shear is long wavelength variability.
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- Mean Turbulence is over convective boundary layer

Isidis Overview

- Mesoscale model runs in progress
- Locally flat plain
  - Likely to have significant convection
  - Possibly modified by tropical jet
- Large topographic relief to south
  - Relatively close (< 50 km)
  - May drive katabatic winds
  - Could generate remnant nighttime downslope flow
- May be affected by mid-latitude baroclinic storms
- Basin has many local dust storms

Best guess is intermediate between Hematite and Gusev

Summary

	Hematite		Gusev		Melas	
	MRAMS	Mars MM5	MRAMS	Mars MM5	MRAMS	Mars MM5
Wind Speed (m/s)						
Horizontal	4 ± 2	4 ± 2	7 ± 2	3 ± 0.6	14 ± 5	$1.3^{*} \pm 0.7$
Upward	2.5(1.9)	1.4	0.4	0.3	0.7	0.1
Downward	$-1.1(-1.5)$	-1.7	-0.2	-0.3	-0.8	-0.1
MPF Scale Factors						
Shear	0.4(0.3)	0.2	0.9	0.5	0.8	0.5
Turbulence						
Average	0.7		1.8		1.6	
Peak	1.2		2.1		2.8	

* Speeds are signficantly higher 2 hours later (6 ± 3 m/s)

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